Nondestructive Evaluation Program

Electric Field Imaging of Tribolectric Charged Materials (EFI)

Completed Technology Project (2015 - 2018)

Project Introduction

NDE historically has focused technology development in propagating wave phenomena with little attention to the field of electrostatics and emanating electric fields. This work is intended to bring electrostatic imaging to the forefront of new inspection technologies, and new technologies in general. The specific goals are to specify the electric potential and electric field including the electric field spatial components emanating from, to, and throughout volumes containing objects or in free space.

Objectives

Development of new inspection technology for quantitative evaluating integrity of wire insulation, structural components, dielectric properties, electrostatic charge (ESD), locating and characterizing hidden objects, remote monitoring and characterization of human electrochemical activities.

Background

NDE historically has focused technology development in propagating wave phenomena, such as, X-ray, N-Ray, ultrasonic, microwave, thermal, terahertz, and eddy current with little attention to the field of electrostatics and emanating electric fields. This work is intended to bring electrostatic imaging to the forefront of new inspection technologies, and new technologies in general. The specific goals are to specify the electric potential and electric field including the electric field spatial components emanating from, to, and throughout volumes containing objects or in free space.

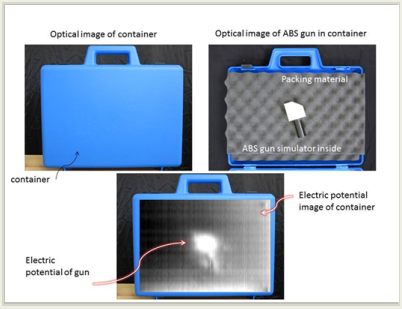
This work will be based on the original electric field sensor (e-Sensor) work disclosed by Generazio (2002). Current efforts have been focused on understanding the e-Sensor sensitivity and understanding the environment in which the e-Sensor is responding to.

Customers

NASA Programs, ESD mitigation programs, astronaut health monitoring, military, public transportation safety, medical community, and computer technology developers.

Milestones

FY16: Design 2D e-Sensor array and establish calibration protocols
FY17: Test array for imaging electronic& structural components
FY18: Document capability of 2D array



ABS plastic gun detected with with EFI technology. Credit: NASA/LaRC

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Project Manager

Edward R. Generazio (Retired)

New contact: Eric Burke DPM, 757-864-7724, eric.r.burke@nasa.gov

References

Generazio, E. R. (November 19, 2013). Ephemeral Electric Potential and Electric Field Sensor; USTPO 61/906,068.

Generazio, E. R. (February 4, 2011). *Electric Field Quantitative Measurement System and Method, USTPO 13/020,025 .*

Generazio, E. R. (March 13, 2013). *Quasi-Static Electric Field Generator, USTPO 13/800,379 .*

Anticipated Benefits

All missions

* Electrostatic discharge (ESD) control requirements

* Electronic signature requirements, as received and damaged materials characterization requirements,

* Vehicle and component charging requirements

* Design and construction of unique electronic sensors

* Systems and human health monitoring in space.

Organizational Responsibility

Responsible Mission Directorate:

Office of Safety and Mission Assurance (OSMA)

Lead Center / Facility:

Langley Research Center (LaRC)

Responsible Program:

Nondestructive Evaluation Program

Project Management

Program Director:

Terrence W Wilcutt

Program Managers:

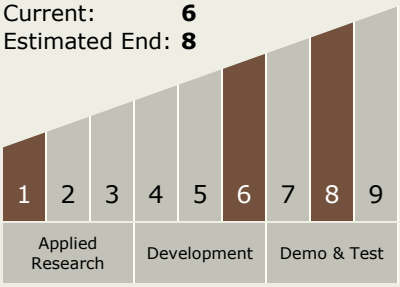
Jeannette F Plante
Jason P Moore
Eric R Burke

Project Manager:

Edward R Generazio

Technology Maturity (TRL)

Start: **1**
Current: **6**
Estimated End: **8**



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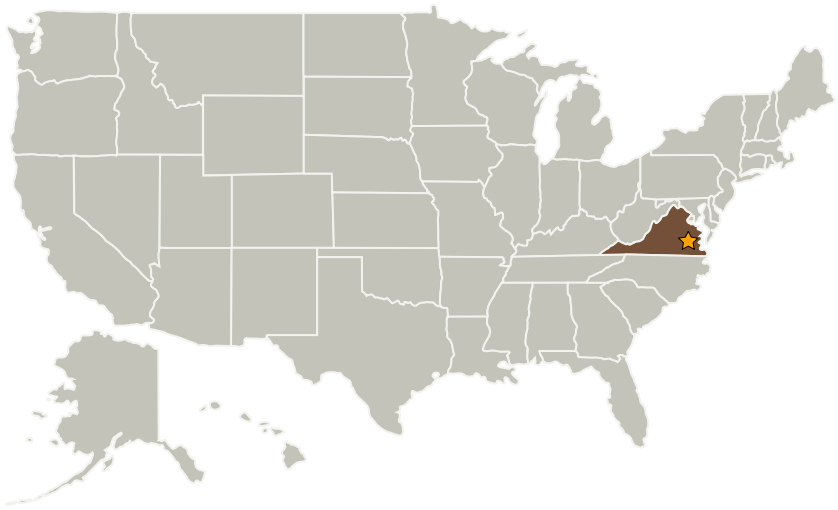
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Langley Research Center(LaRC)	Lead Organization	NASA Center	Hampton, Virginia

Co-Funding Partners	Type	Location
Office of Safety and Mission Assurance(OSMA)	NASA Office	

Primary U.S. Work Locations
Virginia

Project Transitions

October 2015: Project Start

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.1 Materials
    - TX12.1.6 Materials for Electrical Power Generation, Energy Storage, Power Distribution and Electrical Machines

Target Destination

Foundational Knowledge

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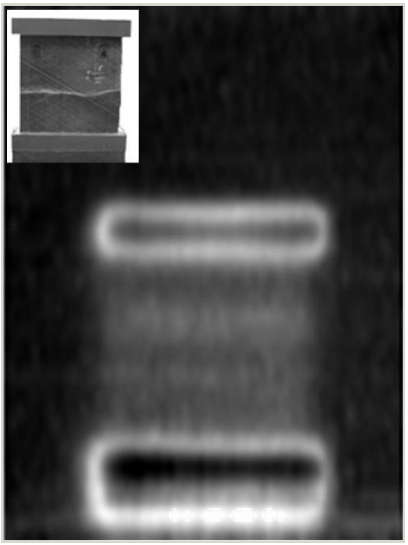
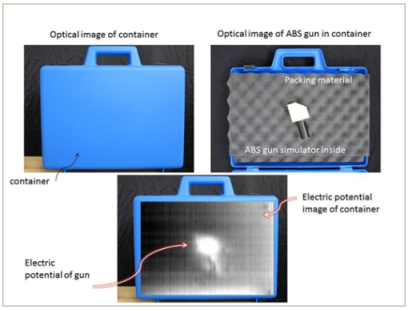
September 2018: Closed out

Closeout Summary: Reported in SE&R Webinar: "Electric Potential and Electric Field Imaging", https://youtu.be/grkOT4P-m44The technology and techniques for remote quantitative imaging of electrostatic potentials and electrostatic fields in and around objects and in free space was successfully investigated, resulting in new imaging technology. Electric field imaging (EFI) technology may be applied to characterize intrinsic or existing electric potentials and electric fields, or an externally g enerated electrostatic field made be used for volumes to be inspected with EFI. The baseline sensor technology (e-Sensor) and its construction, optional electric field generation (quasi-static generator), and current e- Sensor enhancements (ephe meral e-Sensor) are discussed. Critical design elements of current linear and real-time two-dimensional (2D) measurement systems are highlighted, and the development of a three dimensional (3D) EFI system is presented. Demonstrations for str uctural, electronic, human, and memory applications are shown. Recent work demonstrates that phonons may be used to c reate and annihilate electric dipoles within structures. Phonon induced dipoles are ephemeral and their polarization, strengt h, and location may be quantitatively characterized by EFI providing a new subsurface Phonon-EFI imaging technology. Res ults from real-time imaging of combustion and ion flow, and their measurement complications, will be discussed. Extensions to environment, Space and subterranean applications will be presented, and initial results for quantitative characterizing ma terial properties are shown. A wearable EFI system has been developed by using fundamental EFI concepts. These new EFI capabilities are demonstrated to characterize electric charge distribution creating a new field of study embracing areas of in terest including electrostatic discharge (ESD) mitigation, manufacturing quality control, crime scene forensics, design and materials selection for advanced sensors, combustion science, on-orbit space potential, container inspection, remote charac terization of electronic circuits and level of activation, dielectric morphology of structures, tether integrity, organic molecula r memory, atmospheric science, weather prediction, earth quake prediction, and medical diagnostic and treatment efficacy applications such as cardiac polarization wave propagation and electromyography imaging.

Images



EFI
Electric field image of a horizontally-cracked composite laminate plate tensile test specimen.
(https://techport.nasa.gov/image/17667)



Electric Field Imaging
ABS plastic gun detected with with EFI technology. Credit: NASA/LaRC
(https://techport.nasa.gov/image/18393)

Stories

U.S. Patent. Generazio, E. R. (January 31, 2017). Quasi-Static Electric Field Generator, patent US 9,559,616 B2
(https://techport.nasa.gov/file/45534)

U.S. Patent. Generazio, E. R. (March 8, 2016). Electric Field Quantitative Measurement System and Method, patent US 9,279,719 B2
(https://techport.nasa.gov/file/45535)

U.S. Patent. Generazio, E. R. (October 31, 2017). Ephemeral Electric Potential and Electric Field Sensor; patent US 9,804,199 B2
(https://techport.nasa.gov/file/45533)

U.S. Patent. Generazio, E.R., Solid State Ephemeral Electric Potential and Electric Field Sensor, patent US 10,024,900 B2
(https://techport.nasa.gov/file/45496)

Links

Presentation, "Electric Potential and Electric Field Imaging with Dynamic Applications & Extensions"
(https://ntrs.nasa.gov/search.jsp?R=20170011604)

Quasi-Static Electric Field Generator
(http://www.techbriefs.com/component/content/article/1264-ntb/tech-briefs/electronics-and-computers/20952)

Video: SE&R Webinar Electric Potential and Electric Field Imaging
(https://youtu.be/grkOT4P-m44)

Project Website:

https://youtu.be/grkOT4P-m44